Analysis of Drell-Yan longitudinal double spin asymmetry in polarized p + p collisions at PHENIX

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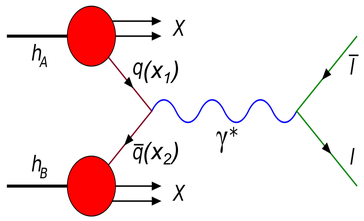
Motivation

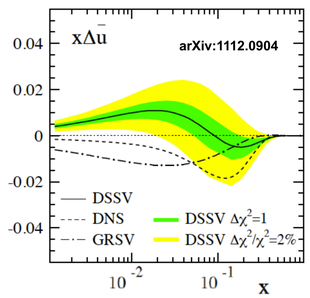
Sidney Drell and Tung-Mow Yan in 1970 investigated the process of virtual photon production due to quark-antiquark annihilation in hadron-hadron collisions leading to a di-lepton final state.

In longitudinally polarized p + p collisions the Drell-Yan process is sensitive to the light quark polarizations:



$$A_{LL}^{DY} = -\frac{\sum_q e_q^2\{\Delta q(x_1)\Delta\bar{q}(x_2) + \Delta\bar{q}(x_1)\Delta q(x_2)\}}{\sum_q e_q^2\{q(x_1)\bar{q}(x_2) + \bar{q}(x_1)q(x_2)\}}$$

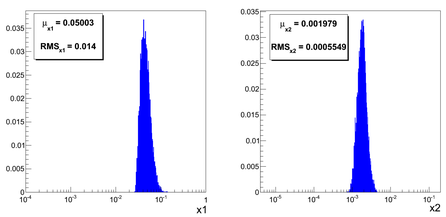
In the limit of $x_1 >> x_2$, ...,



At RHIC, ū interactions are dominant (~84%) in Drell-Yan.

$$A_{LL}^{DY}(x_1, x_2) \approx -\frac{\Delta u(x_1)\Delta\bar{u}(x_2)}{u(x_1)\bar{u}(x_2)}$$

At PHENIX for dimuon intermediate masses (4.5 GeV - 8 GeV) and forward rapidity ($1.2 < |\eta^{\mu}| < 2.4$), the average x_1 and x_2 are approximately 0.05 and 0.002, respectively.

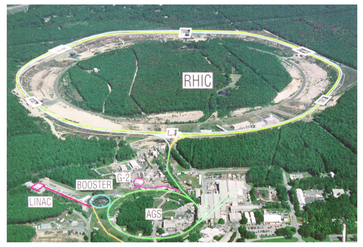


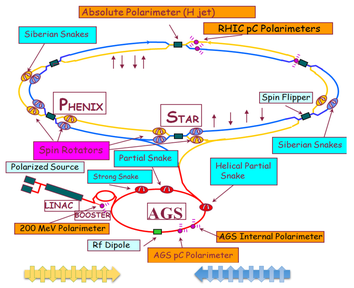
x1 and x2 in PHENIX Forward region for 510 GeV p + p

Hence Drell-Yan A_{LL} can cleanly access the ū polarization $\Delta\bar{u}(x_2)/\bar{u}(x_2)$ at very low x_2 (x_2 ~ 0.002) at RHIC as we have a good knowledge of u quark polarization $\Delta u(x_1)/u(x_1)$ from (SI)DIS measurements.

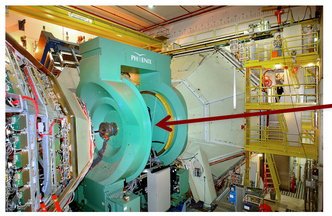
RHIC and PHENIX

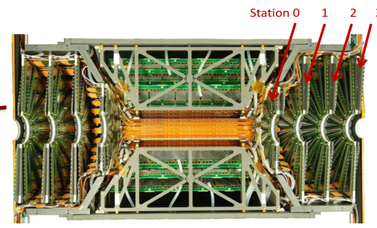
RHIC is the world's only machine capable of colliding high-energy beams of polarized protons, and is a unique tool for exploring the proton's 'missing' spin.





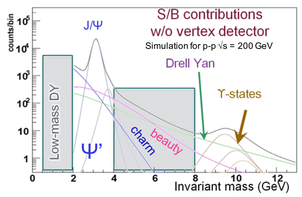
PHENIX Pioneering High Energy Nuclear Interaction eXperiement





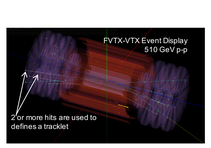
Signal Fraction

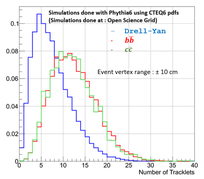
One of the dominating backgrounds for the Drell-Yan analysis in intermediate mass region is from open heavy flavor production.

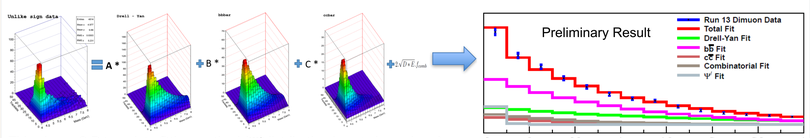


FVTX tracklet distribution is a great tool to distinguish heavy flavors from Drell-Yan process.

Multi-dimensional likelihood fitting is used to extract the Drell-Yan fraction of the dimuon data.



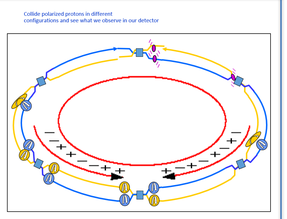




This shows 2-D template fitting method (Ψ/ distribution is not shown here)
A, B, C are constant free parameters. Comb : Combinatorial Background

Asymmetry

$$A_{LL} = \frac{1}{|P_1P_2|}\frac{N_{++}/L_{++} - N_{+}/L_{+}}{N_{++}/L_{++} + N_{+}/L_{+}}$$



During the 2013 RHIC run, the PHENIX experiment collected 146 pb^{-1} of longitudinally polarized p+p data at $\sqrt{s}$ = 510 GeV/*c* with an average beam polarization of 52%.

Inclusive asymmetries and signal and background fractions are measured at two mass bins and four tracklet bins. Then they are used to extract the Drell-Yan A_{LL}.

$$A_{LL}^{inc} = (1 - F_{hf} - F_{comb}).A_{LL}^{DY} + F_{hf}.A_{LL}^{hf} + F_{comb}.A_{LL}^{comb}$$

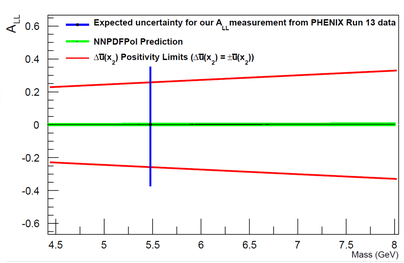
F_x = Fraction for process x
$A_{ll}^{x} = A_{LL}$ for process x

Summary & Future Work

In the PHENIX experiment at RHIC, the Forward Silicon Vertex Detector (FVTX), together with forward muon spectrometers, allows us to study the Drell-Yan process by detecting the muon pairs in the forward region ($1.2 < |\eta^{\mu}| < 2.4$) while also suppressing backgrounds due to heavy-flavor production.

This analysis will provide the measurement of the Drell-Yan cross-section and the longitudinal double spin asymmetry which could be used for the 1st measurement for $\Delta\bar{u}/\bar{u}$ at very low x (x~0.002).

The prediction for Drell-Yan A_{LL} at PHENIX in the forward region.



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